How Much Condensed Water Does It Take to Make "Cloud?"

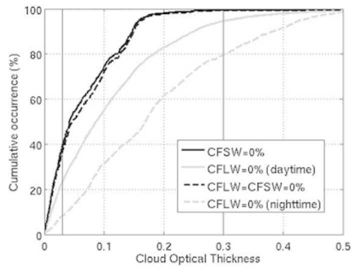
Contributors
Chuck N. Long, *Pacific Northwest National Laboratory*; Jean-Charles Dupont, *Laboratoire de Météorologie Dynamique (LMD), IPSL*; Martial P. Haeffelin, *Institut Pierre Simon Laplace*

Research Highlight

Studies of cloud radiative forcing, cloud effects, and cloud feedbacks all inherently include some form of definition of what is and is not a "cloud." In other words, how much and/or how concentrated must condensed water in the atmospheric column be before it is considered to be "cloudy" rather than "cloud-free?" With respect to aerosol forcing, precise methods to distinguish condensed water from other aerosols (e.g., mineral or moist hydrophilic aerosols) is needed. Lidars are known to be particularly sensitive to the presence of condensed water and aerosols in the column, where any signal detectable above the instrument noise level is labeled either a cloud or aerosol layer base height. Thus, most often a comparison of time series cloud fraction from lidar data with corresponding cloud fraction from other methods (sky imagers, human observations, irradiance analyses, etc.) gives a significantly larger cloud fraction value for the lidar. A precise definition in some relative radiative physical term as to where the cloud/no cloud "line has been traditionally drawn" is needed in order to relate the two types of data.

Using the Radiative Flux Analysis methodology developed under the ARM Program, we compare cloud-free periods detected by an analysis of shortwave (SW) and longwave (LW) irradiance time series with corresponding lidar detections of condensed water or ice in the column. We find that situations classified as cloud-free by analysis of SW (LW) measurements are also classified as cloud-free (no discernable lidar significant level of return) by the lidar in more than 60% (50%) of the cases. The remaining 40% (50%) of the cases are classified as "condensed water detected in the column" by the lidar, and are hence considered as hazy. These hazy situations are predominantly (90%) composed of high-altitude (average 9.5 km height) cirrus clouds, partitioned equally between subvisible and semi-transparent optical thickness classes. We find that, in hazy situations, the average cloud radiative forcing on surface downwelling SW is on average 5 Wm-2 out of 375 Wm-2 total SW irradiance, but can reach values of 15 Wm-2. The SW algorithm effectively produces a "cloud-free" definition for visible optical depths of 0.15 and less.

This study now establishes a definition of the delineation between cloud-free and cloudy by the Long and Ackerman (2000), and cloud fraction estimations by the Long et al. (2006), SW analysis techniques in terms of visible optical depth. Since these SW techniques were developed using corresponding sky imager and human sky observations, the same cloud/no cloud optical depth limit is also largely applicable to these more traditional sky observations.



Cumulative occurrence of the cloud optical depth during hazy situations for the SW detected cloudless sky (CFSW=0), LW detected cloudless sky (CFLW=0), and when both SW and LW cloudless skies are detected (CFSW=CFLW=0). Vertical lines correspond to class limit of subvisible and semi-transparents cirrus clouds.

Reference(s)

Dupont JC, M Haeffelin, and CN Long. 2008. "Evaluation of cloudless-sky periods detected by shortwave and longwave algorithms using lidar measurements," Geophysical Research Letters 35:10, doi:10.1029/2008GL033658.

Office of Science
U.S. DEPARTMENT OF ENERGY

Long, C. N., and T. P. Ackerman. 2000. Identification of clear skies from broadband pyranometer measurements and calculation of downwelling shortwave cloud effects, J. Geophys. Res. 105, No. D12, 15609-15626.

Working Group(s)
Radiative Processes

Office of Science
U.S. DEPARTMENT OF ENERGY